ASSESSMENT OF THE EFFICIENCY WORK OF SURFACE MINERS OF THE MILLING TYPE ON IRON ORE PITS

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Subject research. A significant part of the costs associated with ore mining belongs to drilling and blasting operations. Therefore, one of the ways to improve the performance of mining enterprises is to improve drilling and blasting operations or the use of a non-blasting method of preparing rocks for excavation using surface miners. To obtain the correct results of the use of surface miners, it is necessary to assess their effectiveness in the conditions of open development of iron ore deposits, as an alternative to drilling and blasting.

Methodology. The analytical method of research, which takes into account the influence of different indicators on the effectiveness of the use of combine layer milling, is used. Based on the mathematical method takes into account the patterns and dependencies that enable you to compare the two ways of weakening the rock massif, covering the theoretical and practical parameters of their work.

Purpose. To evaluate the efficiency of milling-type surface miners on the basis of their comparison with traditional drilling and blasting operations in the development of half-rocky rocks and rocky rocks.

Conclusion study. The presented method of obtaining an assessment of the efficiency of surface miners in the development of iron ore, makes it possible to compare the non-blasting method of rock development and the method of softening the rock massif using drilling and blasting. On the basis of the obtained assessment it follows that the implementation of the combine method of mining has lower energy costs and better performance of mining operations.

Introduction

Increasing the intensity of production of iron ore requires reducing the cost of technological processes of mining timely to perform drilling and blasting operations. Therefore, there is a need to improve and develop more significant technological and technical solutions regarding the method of preparation of rocks for excavation.

In recent years, due to the environmental situation of mining enterprises and the constant increase in energy prices, career harvesters around the world have become increasingly important [1-12].

Experience in the operation of milling-type mountain combines in the development of rocks with a fortress coefficient of up to f=15 with the presence in the rock mass of various inclusions with a strength factor of f>20 on the scale of M. Protodyakonov, which indicates the possibility of using them quite effectively in iron ore pits.

Research and solving problems on the effective use of technology of layer-by-layer milling of rocks requires the study of the nature of the influence of physical and mechanical properties of rocks on the working body of the combine and the conditions for the development of rocks combine layer-by-layer milling.

Complex geological and mining conditions for the development of iron ore quarries when reaching significant depths of working off the rock mass with the use of combines layer-by-layer milling improves the technical and economic performance of the open pit.

To evaluate the efficiency of milling-type surface miners on the basis of their comparison with traditional drilling and blasting operations in the development of half-rocky rocks and rocky rocks. Achieving this goal is formed on the consideration and solution of the following tasks:

to carry out the analysis of preparation of rocks for excavation by explosion;

to analyze the destruction of rocks by open pit combines of milling type and the nature of rock softening taking into account their physical and mechanical properties;

to analyze and justify the indicators that affect the formation of a qualitative assessment of the effective use of career combines milling type.

To determine the quantitative characteristics of the reliability of modern removal and loading equipment need statistics that can be obtained in the implementation of the operation of the combine or take the results of the analysis studies.

Obtaining statistical data of harvesters is problematic due to the lack of the ability to test them in the right operating conditions and the difficulty to obtain statistical data during bench tests, due to the lack of alternative materials.

The analytical method of research, which takes into account the influence of different indicators on the effectiveness of the use of combine layer milling, is used. Based on the mathematical method takes into account the patterns and dependencies that enable you to compare the two ways of weakening the rock mass, covering the theoretical and practical parameters of their work.

Further evaluation of the effectiveness of the application of surface miner milling type will be formed on the basis of the work of such scientists as: Yu.I. Anistratov, I.A. Tanaeva, I.J. Repik and L.I. Baron.

Some theoretical and practical results of operation of career combines of layer milling at the mining enterprises are considered. The analysis of the obtained characteristics of harvesters in the conditions of open development of mineral deposits, indicates a sufficient level of effective use of milling combines and makes it necessary to justify the production technology of layered milling in iron ore pits.

The definition rational type surface miners

Based on the calculation of energy costs, it is possible to determine the power of the power plant of a milling type surface miner, which is required to obtain the required size of a piece of softened rock. To determine the specific energy consumption required to perform layer-by-layer milling of rocks by a combine, it is necessary to compare them with the specific energy consumption for the destruction of rocks by roller drilling machines. We use the Kirpichev-Kik law, the formula of which has the following form, kV·h/m^3

$$E_{sm} = \frac{E_b}{ln(\frac{d_{ave}}{d_b})}, \tag{1}$$

where d_{ave} - the average size of a piece softened rock milling combine, mm;

E_b - specific energy consumption of roller drilling, kV·h/m^3;

d_b - particle size softened rocks rolling cutter drilling wells (d_b=5 mm).

The value of the energy intensity of rock drilling roller machines SBSH-250, according to research I.A. Tangaev, is a characteristic of the strength properties of rocks and is determined by the formula, kV

$$N_b = N_p + N_x, \tag{2}$$

where N_b - total engine power needed for the weakening of the breed of the rotary drilling machine, kV;

N_p - the required motor power for the weakening of the breed of the rotary drilling machine, kV;

N_x - idle power system of the drilling rig (N_x=8÷10 kV at the SBSH-250MH), kV.

When the formula (1) is transformed, it will have the following form, kV·h/m^3

$$E_b = \left(\frac{E_p}{k_u} \right) + \left(N_x \cdot \frac{t_b}{V_{wel}} \right), \tag{3}$$

where E_p - the specific energy absorption of the breeds in the process of performing drilling, kV·h/m^3;

t_b - the time of the drilling of the well, h;

V_{wel} - the volume of the borehole, m^3;

k_u - efficiency of energy use in the performance of roller drilling (about 0.6%).

Determination of the value of E_p is performed by the formula proposed by Yu.I. Anistratov, kV·h/m^3

$$E_p = 2{,}78 \cdot 10^{-7} \left(\frac{\sigma_{com}{}^2}{2E} \cdot lg \frac{d_{wel}}{d_p} + g \cdot \rho \cdot \frac{l_{wel}}{2} \right), \tag{4}$$

where σ_{com} - the tensile strength of rocks in uniaxial compression, Pa;

E - modulus of elasticity, Pa;

ρ - rock density, kg/m^3;

d_{wel} - bore diameter (d_{wel}=250 mm when using SBSH-250), m;

d_p - the average size of sludge particles in rolling cutter drilling (d_p=0.005 m), m;

l_{wel} - length of the blast hole (for iron ore quarries l_{wel} = 18 m at the height of the ledge 15 m), m;

g - acceleration of gravity (g=9.8), m/s^2.

Determine the volume of the well according to the following formula, m^3

$$V_{свр} = 0{,}25 \cdot \pi \cdot d_{wel} \cdot l_{wel} \,. \tag{5}$$

We determine the duration of the net drilling of one well by the formula, h

$$t_b = \frac{l_{wel}}{v_b}, \quad (6)$$

where V_b - technical speed of drilling, m/h.

To determine the value of the drilling speed of the well, you can use the formula B.N. Kutuzov

$$v_b = \frac{14400 \cdot P_o \cdot n_o}{P_k \cdot D_d}, \quad (7)$$

where P_o - the value of the axial force on the bit in the implementation of drilling soft and medium strength rocks, MPa;

n_o - the frequency of rotation of the drill bit, s^{-1};

D_d - bit diameter of the machine SBSH-250, m;

P_k - contact strength of the rock, proposed by L.I. Baron, MPa.

When using drilling rig SBSH-250 accepts the following parameter values: P_o=0,22 MPa; n_o=3,0 s-1; D_d=0,244 m.

To determine the value of the P_k can be calculated using the empirical dependence of the proposed N.Ja. Repin, MPa

$$P_k = 1{,}9 \cdot \sigma_{com}^{1{,}5}. \quad (8)$$

In the future, substituting the corresponding values of the parameters in the formulas (1-8), we obtain the values of the specific costs of the development of iron ore put surface miners. According to the results of calculations, the specific energy intensity of rock softening by surface miner will be determined. Taking into account the specific energy consumption of E_{sc} and the technical performance of the milling combine Q_{sc}, it is possible to determine the necessary power of the power plant by the following formula, kV

$$N = 1{,}15 \cdot E_{sc} \cdot Q_{sc}. \quad (9)$$

Speed of movement of the milling combine at performance of working off of a layer of breeds of weight can be defined by the formula, m/h

$$V_w = \frac{N}{1{,}15 \cdot E_{sc} \cdot B_s \cdot h}. \quad (10)$$

We choose career combines of milling type 4200SM, which have N=1193 kV, B_s=4200 mm, h=0.1÷0.6 m.

Determination productivity milling-type surface miner

An important indicator of the successful operation of the mining enterprise is the maintenance and improvement of the level of productivity of mining equipment, as it affects the further coherence of the complex of technological processes of mining.

Taking into account the necessary data, we determine the performance of the milling combine according to the following formula, m^3/h

$$Q_h = \frac{60 \cdot h \cdot B_s \cdot L_w}{T_o + \frac{L_w}{V_w} + T_t + T_n}, \tag{11}$$

where h - the depth of the rock milling layer, m;

B_s - maximum width of rock milling entering, which corresponds to the length of the milling drum of the quarry combine, m;

L_w - the average length of the front of the working stroke of the surface miner, m;

V_w - speed of movement of the surface miner performing layer-by-layer milling of the massif of rocks, m/min;

T_o - the duration of lowering the working body of the surface miner to the beginning of the layer-by-layer milling of rocks combine (T_o = 0.5), min;

T_t - it takes time for the implementation of the rotation surface miner in the opposite direction to continue testing of rocks (T_t = 6÷8) min;

T_n - the duration of raising the working body of the mining combine prior to performing layer-by-layer milling of rocks combine (T_n=0.3), min.

To determine the operational performance of a mining combine during the change, we use the following formula, m^3/ch

$$Q_{ch} = Q_h \cdot T_{ch} \cdot k_1 \cdot k_2 \cdot k_3, \tag{12}$$

where T_{ch} - the duration of the work shift, h;

k_1 - the factor of time spent on maintenance aggregates mining combine (k_1 = 0.83);

k_2 - factor of the account of expenses of time for implementation of replacement of cutters of the working body of the combine (k_2 = 0.95);

k_3 - time factor for installation and replacement of dump trucks for loading (k_3=0.7).

To determine the annual production capacity of a mining combine is possible by the formula, t/year

$$Q_{year} = Q_{ch} \cdot N_{ch} \cdot N_d \cdot k_u , \qquad (13)$$

where N_{ch} - number of shifts per day;

N_d - number of working days in a year;

k_u - coefficient of use of surface miner during the year (k_u = 0.75).

After determining the annual productivity of a milling type surface miner in the specific conditions of the development of iron ore, the required number of combines is determined to ensure a given performance of the open pit.

Comparison of rock mining methods

Application of technology of layer-by-layer milling of rocks by surface miners in comparison with traditional technology of preparation of rocks for excavation by blasting has characteristic advantages and disadvantages.

Comparison of two methods of rock mass softening can be made on the basis of taking into account the energy absorption of rocks, which is necessary for the actual softening of rocks under the influence of the destruction factor [13,14].

Specific energy absorption in the performance of explosive crushing and formation of the collapse of the softened rock massif can be determined by the following formula, J/kg

$$E_b = \left(\frac{\sigma_{com}^2}{2 \cdot E \cdot \rho} \cdot lg\, n^I + \frac{l_{wel}}{2}\right) \cdot N , \qquad (14)$$

where σ_{com} - tensile strength of rock to uniaxial compression in the implementation of drilling, Pa;

E - modulus of elasticity, Pa;

ρ - density of rock, kg/m^3;

l_{wel} - well depth, m;

N - the ratio between the volume of drilling operations and the volume of the blasting unit.

The resistance of the rock to compression, and N is determined by the formula, m

$$n^{I} = \frac{d_{wel}}{d_{p}},\qquad (15)$$

where d_{wel} - borehole diameter, m;

d_p - diameter piece softened rocks in the drilling process, m.

Specific energy absorption in the destruction of rocks can be determined by the following formula, J/kg

$$E_{v} = \frac{\sigma_{com}^{2}}{2 \cdot E \cdot \rho} \cdot lg\, n^{II} + \Delta + l_{c},\qquad (16)$$

where Δ - the specific energy providing the necessary degree of softening of the blasted rock mass for effective excavation, J/kg;

l_c - the amount of offset of the center of gravity of splitting array of blasted block to the center of the collapse of the rock mass, m.

In the case of using the blasting to prepare the rocks for excavation, the destruction of the rock mass occurs as a result of overcoming the resistance of the rock to stretching σ_{str}. Therefore, the energy absorption of the process of destruction of rocks is proportional to the degree of grinding of rocks, namely the ratio of the size of the cracks of the natural separation of d_{sep} to the desired average size of a piece of softened rock d_{awe} for their effective excavation

$$n^{II} = \frac{d_{sep}}{d_{awe}}\qquad (17)$$

The value of LC is determined by the following formula, m

$$l_{c} = \frac{(c + h \cdot ctg\alpha) \cdot (k_{p} \cdot h - h_{p})}{2 \cdot h_{p}},\qquad (18)$$

where c - the distance between the first row of wells and the upper brow of the ledge, m;

α - the angle of slope of the ledge, degree;

k_p - coefficient of loosening of rock massif;

h_p - the permissible height of the collapse of the rock mass in the face, m.

We determine the ratio between the volume of drilling operations and the volume of the explosive block according to the formula

$$N = \frac{V_{b}}{V_{bl}} = \frac{n_{wel} \cdot S_{wel} \cdot l_{wel}}{h \cdot B \cdot L_{bl}},\qquad (19)$$

where V_b - drilling, m^3;

V_{bl} - the volume of the explosive block, m^3;
n_{wel} - the number of wells of the explosive block;
S_{wel} - area of the blasting well, m^2;
h - the height of the ledge, m;
B - width of the blasting block, m;
L_{bl} - length of the blasting block, m.

The no-vibration method for the development of rocks by milling combines requires specific energy absorption of E_{cut}, which is determined by the following formula, J/kg

$$E_{sc} = \frac{\sigma_{cut}}{2 \cdot E \cdot \rho} \cdot lg\, n^{III}, \qquad (20)$$

Combine how to develop a rock mass fulfills the weakening of rocks due to the resistance of rocks under shear σ_{cut}. Moreover, the degree of grinding of rocks n^{III} is determined by the ratio of the size of the separation of the array to the average size of a piece of waste rock, which is an essential condition for the effective use of mining rock massif reinforced cutters working body of the milling combine.

Conclusions

The results of the study indicate that the presented method of obtaining an assessment of the efficiency of milling combines in the development of iron ore, makes it possible to compare the method of development of rocks and the method of softening the rock massif using drilling and blasting. On the basis of the obtained assessment it follows that the implementation of the combine method of mining has lower energy costs and better performance of mining operations.

Further research will be devoted to the implementation of the introduction of milling type surface miners in the development of iron ore pits on the basis of appropriate technical and economic calculation, taking into account all possible features of the mining enterprise.

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